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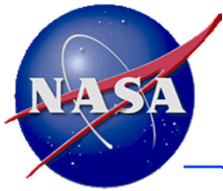
**Navigation and Ancillary Information Facility**

# **A SPICE Update**

**The NAIF Team**

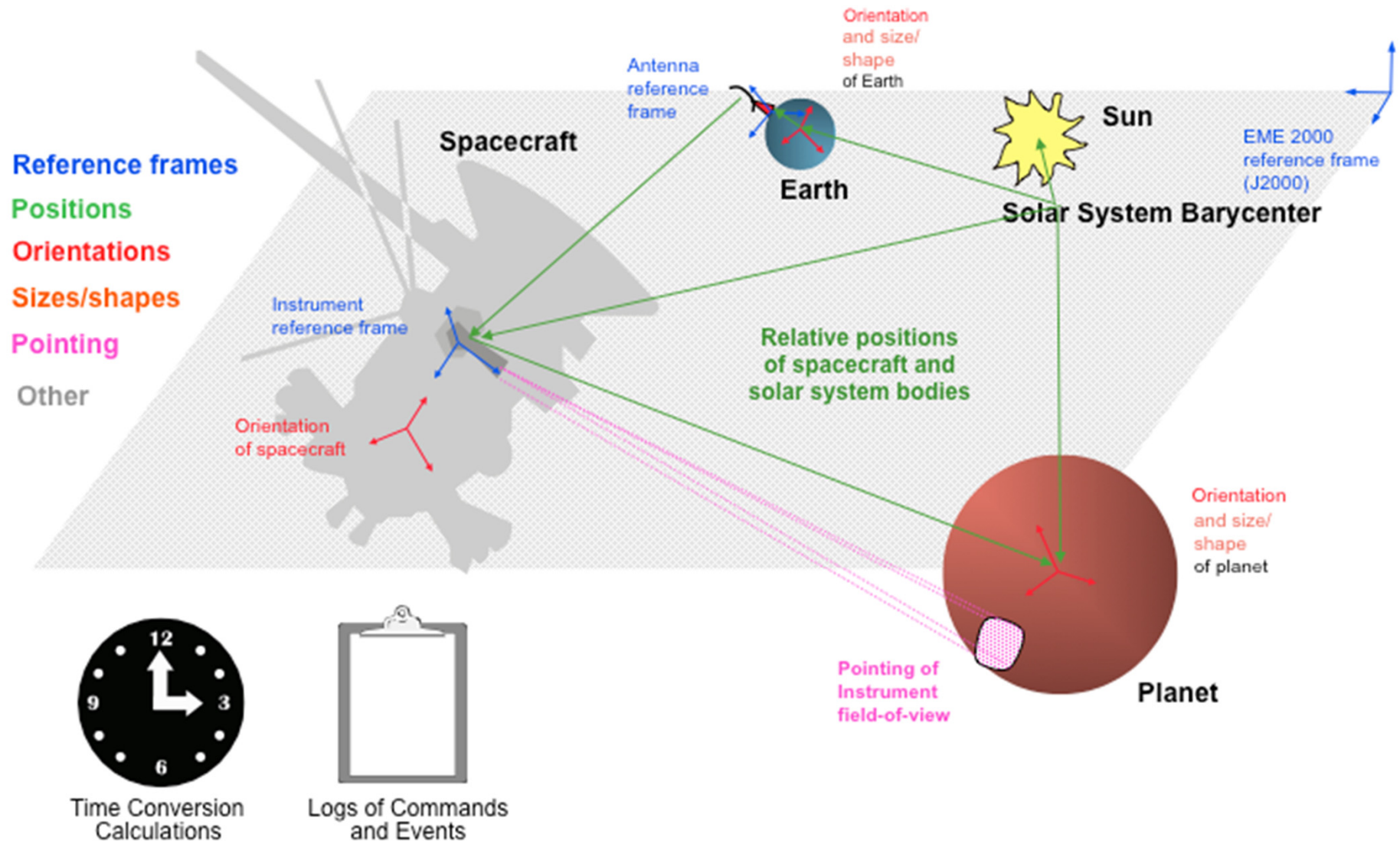
**27 June 2012**

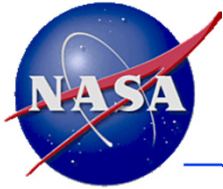
The research described in this publication was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.



# Reminder: “SPICE” Provides Observation Geometry

Navigation and Ancillary Information Facility



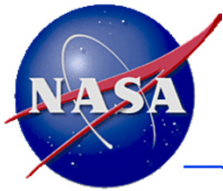


# Agenda

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## Navigation and Ancillary Information Facility

- **We'll provide a summary of:**
  - capabilities no longer new but still not well known
  - capabilities recently added
  - capabilities being worked on now
  - some thoughts about future capabilities
- **We're interested in your feedback:**
  - regarding these “new” capabilities
  - on PDS4 archive meta-data for SPICE
  - on any topics or issues we've not mentioned

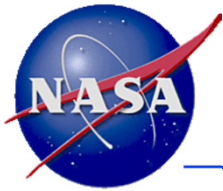


# Not Well Known Dynamic Reference Frame

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Navigation and Ancillary Information Facility

- **A dynamic reference frame...**
  - may be constructed by you
  - has orientation that is time dependent
  - is defined by a formula implemented in SPICE code and for which you provide the parameters via an FK
  - may rely on data from other SPICE kernels
- **Examples on next page**
- **Details and examples are found in:**
  - » “*Dynamic Frames*” tutorial
  - » “*Frames Required Reading*” technical specification document
  - Both are available from the NAIF web pages

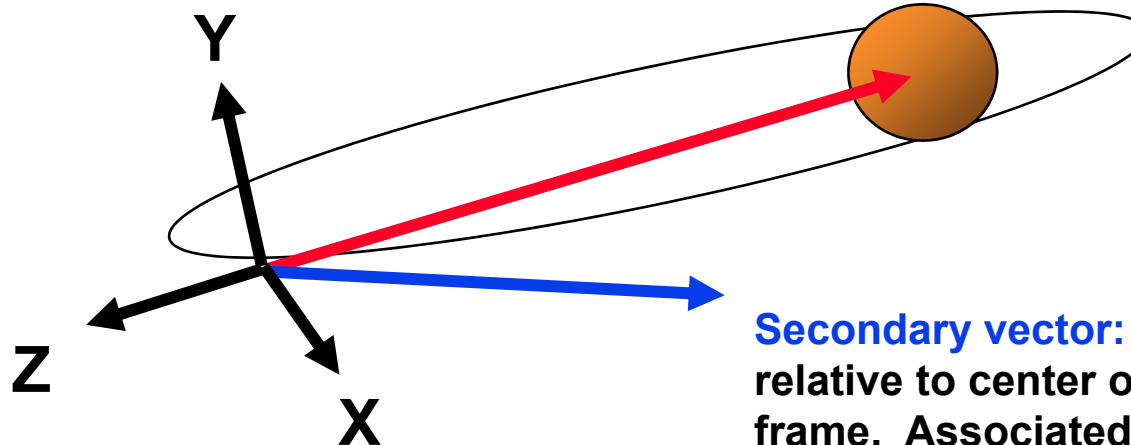


# Example of a Dynamic Frame

Navigation and Ancillary Information Facility

## Nadir-Oriented Spacecraft-Centered Frame

$Y = Z \times X$ , completing the right-handed frame



**Primary vector:** spacecraft nadir direction vector. Associated with nadir frame's -Z axis in frame kernel

Nadir vector can be defined to point to either of:

- the closest point to the spacecraft on the ellipsoid
- the center of mass of the orbited body

**Secondary vector:** spacecraft velocity relative to center of motion in J2000 frame. Associated with nadir frame's +X axis in frame kernel

Normalized component of secondary vector orthogonal to primary vector. This vector is aligned with the nadir frame's +X axis



## Recently Added Geometry Finder Subsystem (GF)

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Navigation and Ancillary Information Facility

- Find time spans when a specified geometric event occurs (*binary state functions*)
  - Examples: occultation, transit, object is in field of view
- or
- Find times or time spans when a specified geometric parameter reaches a max or min, achieves a specified value, or is within a specified range (*numeric functions*)
  - Examples:
    - » Spacecraft altitude is between 200 and 300 km
    - » Phase angle reaches a local maximum
    - » Angular separation of two objects as seen from a third reaches an absolute minimum
- These kinds of computations are possible using “old SPICE,” but the GF modules make them easier to do.



# Geometry Finder Events

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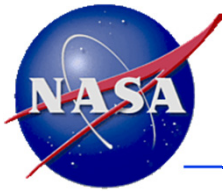
## Binary State Functions

- Occultation or transit
- Ray in instrument field of view
- Body in instrument field-of-view

## Numeric Functions

- Distance
- Range-rate
- Illumination angles
- Angular separation
- Ray-surface intercept coordinate constraint is met
- Sub-observer point coordinate constraint is met
- Position vector coordinate constraint is met

**Still more event searches will be added**



## Being Worked on Now

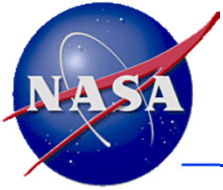
# Extension of Shape Modeling

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Navigation and Ancillary Information Facility

- **Currently SPICE deals with only spheroidal and tri-axial shape models for solar system bodies**
- **The new Digital Shape Kernel (DSK) will accommodate:**
  - **digital elevation models (DEM) for large bodies such as Mars and the Moon**
  - **tessellated plate models for small, irregularly shaped objects such as comets, asteroids and small satellites**



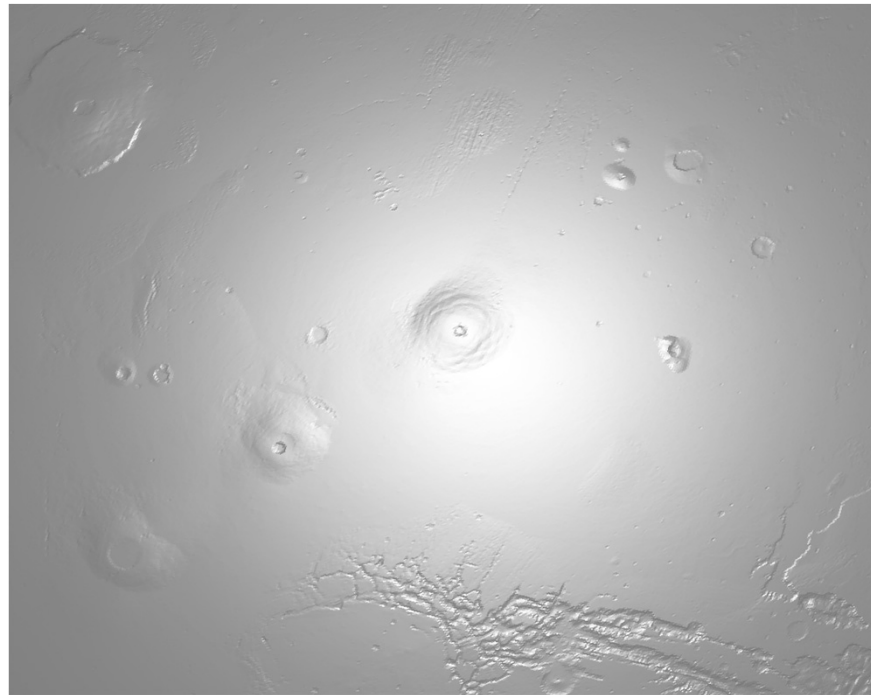


# DSK: Digital Elevation Model

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Navigation and Ancillary Information Facility

- **Maps longitude/latitude to elevation**
  - Elevation of a surface point can be defined as distance from the origin of a body-fixed reference frame
  - Elevation can be defined as height above a reference ellipsoid
- **Example: image created from MGS laser altimeter (MOLA) Mars DEM**

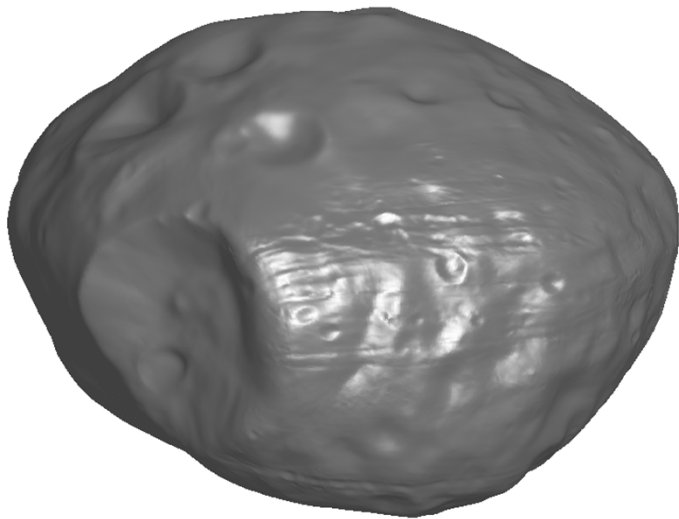




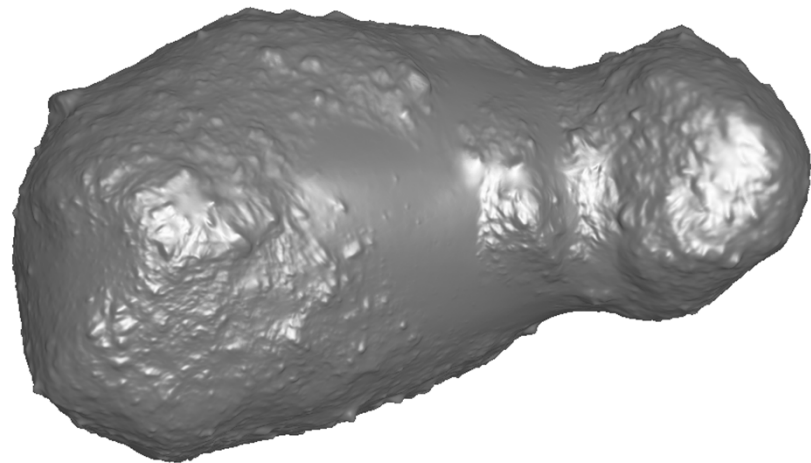
# DSK: Tessellated Plate Model

Navigation and Ancillary Information Facility

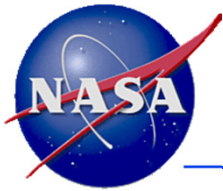
- Surface of object is represented as a collection of triangular plates
- More flexible than digital elevation model: arbitrary 3-D surface can be modeled



Phobos



Itokawa



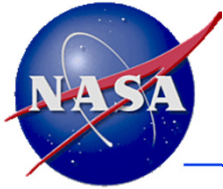
## Being Worked on Now

# Web-based Interface to SPICE

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Navigation and Ancillary Information Facility

- **In partnership with NASA/Ames, NAIF is building a web-based interface to SPICE: “WebGeocalc”**
  - Use your browser to make many kinds of SPICE calculations
  - Will provide some graphical output in addition to numeric data
  - Server is located at NAIF/JPL
    - » But a local instance could be installed by anyone, anywhere
- **Why build it?**
  - Useful to check your own SPICE-based code under development
  - Useful in obtaining a quick back-of-envelope answer
  - Useful in diagnosing geometry problems
  - Opens SPICE capabilities to non-programmers
- **Major challenge is the usual one...**
  - ... kernel management!



# WebGeocalc Inputs

## Navigation and Ancillary Information Facility

**Web Geocalc**  
Version 1.0-SNAPSHOT.1448

New Calculation

Calculation

State Vector

Calculate the position and velocity of a target body with respect to an observing body, as represented in the coordinate frame.

Select Mission:

2001 Mars Odyssey

?

Target:

PHOBOS

Body or spacecraft name or code

?

Observer:

MARS ODYSSEY

Body or spacecraft name or code

?

Observer Time:

☐ Single ☒ Time Range

Calendar date

2008 Jan 01

UTC

?

E.g. 1996-12-18T12:28:28 or other formats

End Time:

2008 Apr 01

Step:

1

Days

Light-Time and Stellar Aberration Correction:

No Correction

?

State Representation:

Right Ascension, Declination, Range

?

Reference Frame:

IAU\_MARS

?

Plot Results:

☐ Distance ☐ Velocity ☒ RA ☒ Dec ☐ RangeRate ☐ RaRate ☐ DecRate

?

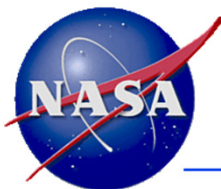
CalculateClear Form

Saved Values

No saved values

Kernels

Meta Kernel Auto Selected for Mission 2001 Mars Odyssey



# WebGeocalc Outputs

## Navigation and Ancillary Information Facility

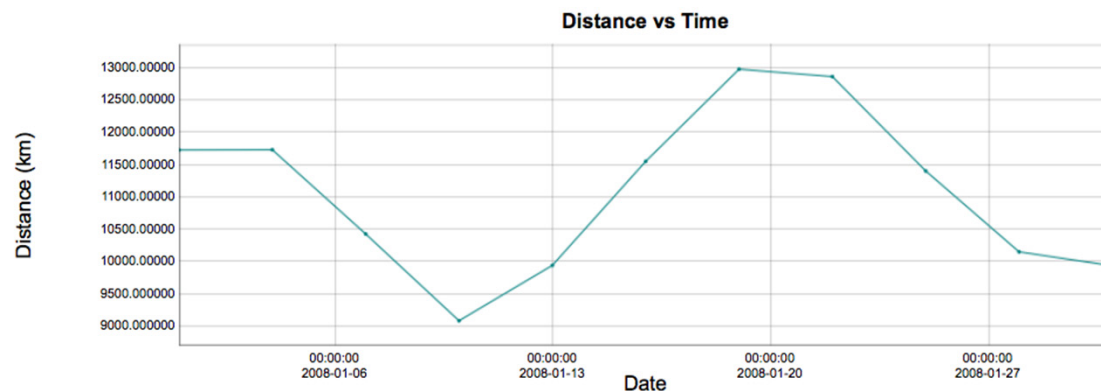
### Input Values

Target PHOBOS  
 Observer MARS ODYSSEY  
 Reference Frame IAU\_MARS  
 Aberration Correction No Correction (NONE)  
 Observer Time 2008 JAN 01 UTC  
 Stop Time 2008 FEB 01 UTC  
 Step 3 day  
 State Representation Right Ascension, Declination, Range

### Results

Click to save values for a future calculation.

	Time	Range (km)	RA (deg)	Dec (deg)	Range Rate (km/s)	RA Rate (deg/s)	Dec Rate (deg/s)	Velocity (km/s)
1	2008-01-01 00:00:00.000000 UTC	11733.67045338	135.29701457	-11.40475910	0.40220836	-6.92557186E-06	0.00023797	2.82216729
2	2008-01-03 23:59:59.999913 UTC	11737.01795821	321.30132980	15.85060399	2.13915789	3.34632796E-05	-0.00019963	3.19508943
3	2008-01-06 23:59:59.999826 UTC	10434.67835236	136.22303711	-20.65234810	2.88233958	0.00024237	0.00013852	3.99972788
4	2008-01-09 23:59:59.999740 UTC	9091.52206689	305.54372246	22.05559594	1.83560999	0.00050720	4.03342189E-05	4.66572024
5	2008-01-12 23:59:59.999653 UTC	9948.12897829	108.64019134	-15.93419775	-0.54777427	0.00039647	-0.00024213	4.52617326
6	2008-01-15 23:59:59.999568 UTC	11557.40506489	281.63697360	7.01424057	-1.32858018	0.00018082	0.00027912	4.05884599
7	2008-01-18 23:59:59.999483 UTC	12983.27060437	106.04445361	-0.24658433	-0.30976170	7.97551860E-05	-0.00025523	3.48550434
8	2008-01-21 23:59:59.999400 UTC	12868.67820501	287.67796970	-6.83063338	1.15223189	0.00010172	0.00024581	3.60869833
9	2008-01-24 23:59:59.999318 UTC	11408.86956466	110.33921120	13.37795657	1.90663471	0.00024495	-0.00024123	4.31289096
10	2008-01-27 23:59:59.999238 UTC	10157.35114896	279.81034886	-19.95132620	0.68579615	0.00046823	0.00013031	4.71251810
11	2008-01-30 23:59:59.999160 UTC	9941.22446039	83.28976932	21.20190237	-1.62136705	0.00047255	9.81033442E-05	4.77092839



No saved values

### Kernels

Meta Kernel Auto Selected for Mission 2001 Mars Odyssey



**Soon to be Underway**

# **PDS4 Meta-data for SPICE Archives**

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Navigation and Ancillary Information Facility

- **The PDS4 development provides an opportunity to extend the kinds of meta-data associated with a SPICE archive.**
- **What suggestions do you have for adding new kinds of summary information to SPICE archives to make it easier for you to select and download SPICE data of interest?**

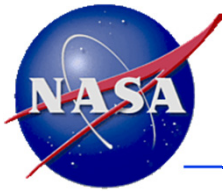


# Other Items “Underway”

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Navigation and Ancillary Information Facility

- **For release in the upcoming N65 Toolkits (~July)**
  - More “geometry finder” modules
  - A number of other new APIs
  - Some code performance improvements (speed up)!
- **Java Native Interface (JNI) Toolkits**
  - In progress; alpha-test versions available now for trial
  - Completion perhaps in first quarter of CY2013
- **Python Toolkits**
  - Some preliminary work done
  - No prognosis for completion



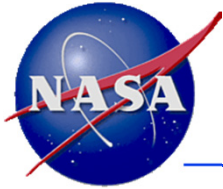
# Still Other Ideas

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## Navigation and Ancillary Information Facility

- **Provide a frames kernel generation and visualization tool**
- **Provide a sky (star) catalog**
  - Development was about 90% completed, then dropped
  - Any interest in this?
- **Provide a generic dynamic frames kernel**
  - Would contain specifications for an assortment of widely used dynamic reference frames
  - Examples: Geocentric Solar Ecliptic (GSE), Solar Magnetic (SM), Geocentric Solar Magnetospheric (GSM), Geomagnetic (MAG), Geocentric Solar Equatorial (GSEQ), Nadir-oriented frame for planetary orbiter, etc.
- **Provide an instrument footprint coverage computation capability**
- **Provide more target models, such as rings, atmosphere, gravity, magnetosphere, ...**
- **Develop a more complete instrument modeling mechanism (e.g. handle geometric calibration)**





# Your Ideas?

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Navigation and Ancillary Information Facility

- **What would you like NAIF to implement, or fix?**
  - Tell us now or later on during this workshop
  - Write it down on the SPICE poster
  - Send us an email